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INTRODUCTION

The University of Alabama in Huntsville contributes to the Technical Management of the Midcourse Space Experiment Program, to the Certification of the Level 2 data produced by the Midcourse Space Experiment's suite of in-orbit imaging radiometers, imaging spectro-radiometers and an interferometer and to the Transfer of the Midcourse Space Experiment Technology to other Government Programs. The Technical Management of the Midcourse Space Experiment Program is expected to continue through out the spacecraft's useful life time. The Transfer of Midcourse Space Experiment Technology to other government elements is expected to be on a demand basis by the United States Government and other organizations. The University of Alabama Huntsville' contribution specifically supports the Principal Investigator's Executive Committee, the Deputy Principal Investigator for Data Certification and Technology Transfer team, the nine Ultraviolet Visible Imagers and Spectrographic Imagers (UVISI) and the Pointing and Alignment of all eleven of the science instruments. The science instruments effectively cover the 0.1 to 28 micron spectral region. The Midcourse Space Experiment spacecraft, launched April 24, 1996, is expected to have a 5 year useful lifetime. The cryogenically cooled IR sensor, SPIRIT III, performed through February, 1997 when its cryogen expired. A pre-launch, ground based calibration of the instruments provided a basis for the pre-launch certification of the Level 2 data base these instruments produce. With the spacecraft in-orbit the certification of the instrument's Level 2 data base was extended to the in-orbit environment

SCOPE

This Final Report for NASA Grant, NAG8-1342, reports on the work done for the Midcourse Space Experiment between July 1, 1997 and March 31, 1998. A Final Report and Quarterly Reports for Delivery Order Numbers 153 and 171, Contract NAS8-38609, predecessor efforts, cover the work done for the Midcourse Space Experiment Program up to June 30, 1997.

BACKGROUND

All analysis and data products from the Midcourse Space Experiment are reviewed to ensure that misinterpretation and incorrect analytical results do not disseminate from the program. In the past, resources have been wasted as hurried analysis, misinterpreted results and incorrect conclusions were released by parties working on earlier space programs. This led to mistrust of the program's results, contradictory conclusions from the same data, and duplication of effort. The Midcourse Space Experiment program structure was designed to guard against this.

The Midcourse Space Experiment program structure was developed to ensure all processes are reviewed from the collection of data to the analysis and interpretation of data. The Data Certification and Technology Transfer certification is part of the overall certification of all the scientific results of the Midcourse Space Experiment data. A Midcourse Space Experiment Data Management Teams verifies the flow of the data, the Data Certification and Technology Transfer Team certifies the processes which convert the bits to engineering units and a Principal Investigator Executive Committee peer reviews the analysis and the interpretations derived from the data. Thereby, all processes are reviewed from data collection to data interpretation which ensures that all Midcourse Space Experiment products benefit from the overall knowledge within the program.

The Data Certification and Technology Transfer team's data certification process provides the Midcourse Space Experiment Principal Investigator teams with reliable sensor and spacecraft data, provides future users valid databases and procedures for accessing and understanding the Midcourse Space Experiment's data, and the community with correct analysis of instrument performance data products.

PHILOSOPHY

The Midcourse Space Experiment program generated multi-tera-bytes of raw data. The Data Certification and Technology Transfer team cannot review each byte individually to certify this vast database. The Data Certification and Technology Transfer's review technique is similar to a method of process certification used in manufacturing. The Data Certification and Technology Transfer team certifies the sensor performance within its operational bounds as it operates within the environment encountered during ground calibration and in-orbit using a statistics based data analysis. Within the bounds, the sensor's operation and the process by which the sensor raw data is converted to scientific and engineering units, is certified by the Data Certification and Technology Transfer team. The data reduction process is called the CONVERT process. In-orbit measurements of standard calibration sources are used by the sensor engineering teams to improve the sensor's calibration and as a basis for modifications to the CONVERT process if necessary. The Data Certification and Technology Transfer team participates in any process modification, reviews the suggested changes, tests the altered process against standard data sets and certifies the changed process. The irradiance from the standard sources, both on the ground and in-orbit are certified by the Data Certification and Technology Transfer team. To certify a Virtual Level 2 database many processes must be understood, reviewed and analyzed by the Data Certification and Technology Transfer team members. The major technical areas of the Data Certification and Technology Transfer certification plan are the sensor's calibrations, the CONVERT software, and a verification the sensors

operated within their respective operational envelope.

At all stages through the certification process the Data Certification and Technology Transfer team reviews the error allocation budget. The error associated with the calibration process is divided up between all the calibration processes in order to meet the program's performance goals.

IMPLEMENTATION

The Data Certification and Technology Transfer allocates to a Watchdog each Midcourse Space Experiment scientific instrument or a suite of instruments. The Data Certification and Technology Transfer Watchdog is responsible for a detailed certification analysis of the single instrument or suite of instruments allocated. The Watchdog works with the individual instrument Performance Assessment Team. The Data Certification and Technology Transfer team, in turn, performs an independent data analysis and compiles a Certification Report to the Principal Investigators and to the Program Office.

DEPUTY PRINCIPAL INVESTIGATOR

SPIRIT III CERTIFICATION

Meetings with Space Dynamics Laboratory Utah State University SPIRIT III Performance Assessment Team provide an opportunity to set priorities for the SPIRIT III Calibration data analysis and to coordinate the schedules for the CONVERT and Pointing CONVERT Software's completion and release to the Principal Investigator teams. Limited budgets and time constraints dictate the need to carefully coordinate SPIRIT III performance analysis, changes to the CONVERT code and the certification processing necessary to certify the reduced SPIRIT III data. The CONVERT Version 4.1 certification has been completed. Another planned CONVERT Version release, discussed during a Planning Meeting held at the Space Dynamics Laboratory Utah State University, is scheduled for September 1997. The release version is to be either Version 4.2 or Version 5.0 depending upon whether or not algorithm changes will or will not be completed in time for the DCATT's Certification process to be completed by December 1997.

CONVERT VERSION 5

It was agreed during the September Meeting the CONVERT Version released to the DCATT in September 1997 is to be Version 5.0. The CONVERT software work is on schedule and the PC CONVERT schedule, considered to be a lower priority task, will be used as a buffer to assure the UNIX Version is completed on

time. Changes to the CONVERT Driver and Anomaly Viewer, CDAV, fixed known problems and improved the functionality.

A detailed list of work items, updated at the September meeting, reflected the current estimate of whether the result of each item's work will be included in the September 1997 or the March 1998 release Version of CONVERT. The work for both the radiometer and the interferometer is included in this attachment. Many of the items identified at the February 1997 meeting have been completed and are noted with a check mark on the Trip Report for this meeting. The other notations are identified.

It is noted there are about 220 Data Collection Events where the Focal Plane Array Temperature is between 12 and 13 Kelvins. The DCATT Certification is to cover those events where the temperature is 13 Kelvins or below. There are only 11 events above 13 Kelvins and it is considered to be infeasible to modify CONVERT to accommodate these DCEs. The analysis which uses data from these 11 events will need to be Peer Reviewed by the Principal Investigator's Executive Committee before they can be released outside the MSX Program.

A 150 micro-radian shift in the interferometers to radiometer fore-sight alignment is noted between ground calibration and in-orbit operations. The cause is unknown.

CONVERT VERSION 5 USERS MEETING

A SPIRIT III CONVERT Users Meeting is the forum to identify outstanding issues with the recently released Version of the software. The most recent release, Version 5.0, prompted a meeting be held at the Space Dynamics Laboratory Utah State University on January 14, 1998.

Users provided insight to the anomalies they have identified by an examination of their respective Level 2 data sets. The SPIRIT III Performance Assessment Team identified residual errors found from their analysis of instrument characterization data.

S. Taylor and R. Russell presented to the assembled audience for its review and comment the DCATT's CONVERT 5 Level 2A Data Certification results for the Radiometer and the Interferometer respectively.

The SPIRIT III Data Processing Center will maintain a Data Products Website Details. The algorithm changes, bug fixes and functionality enhancements to the radiometer and interferometer sections of CONVERT and Pointing CONVERT Version 5.0 are documented in the meeting's minutes. Known bugs and previously requested enhancements are also shown there. Changes to the Radiometer and the

Interferometer Instrument Products files are shown there also. The known issues with pointing, are listed and discussed in Attachment 6 to a Trip Report submitted to the Program Office.

A PC Version of CONVERT which is in work was demonstrated. The DCATT plans to perform an independent comparison of the Level 2 results produced by this code prior to its release to a broad user community.

A correlated noise in the background, a shift in level of ± 0.35 counts for array C and ± 0.1 counts for arrays D and E, is an issue for the Celestial Background team. The correlation is in phase for array E and is 180 degrees out of phase for array D. The cause is to be investigated by the PAT.

A question arose as to how to correctly report a measurement uncertainty when the peak Signal to rms Noise ratio for a single observation is less than 10 to 1. The suggested procedure is to root sum square the certified uncertainty with the standard deviation of multiple observations.

CONVERT VERSION 6

Open issues to correct residual instrument artifacts remained upon the completion of the CONVERT Version 5. The removal of these artifacts requires changes to the software algorithms, thus a new Version number is required. The Data Certification and Technology Transfer team, the Program Office and the SPIRIT III Performance Assessment Team collaborated to identify and to prioritize the tasks which will support effectively the production of a CONVERT Version 6. This meeting followed the CONVERT 5 Users Meeting.

A CONVERT Version 6 will eliminate the residual problems. Within the constraints imposed by the Program's available time and resources, the identification and prioritization of tasks is critical to use effectively the time and resources available. It is expected the Version 6 will be the final Version of the code.

The CONVERT Version 6 Tasks and their priority follow. They are ranked in descending priority as 1, 2, 3, H and L.

Two tasks are the DCATT's responsibility. The Point Response Function over the field of regard will a DCATT product distributed by the DCATT to the PI teams. A Global Minimization of the SPIRIT III's calibration errors is in work by the DCATT.

1. Do integration mode normalization as a function of temperature.
2. Correct a residual array to array goniometric bias of 20 micro-radians.

- 3. Add anti-anti-aliasing in the IFR to fix the forward-reverse scan amplitude difference.
- H. Reprocess the IFR data to reduce uncertainty and create new data products after CONVERT is delivered.
- H. Modify CONVERT to accept Level 2 output data as an input.
- H. Do Stellar benchmark trend.
- H. Remove pointing bias change (drift) with time. Make this the default. Add an option to turn this bias removal off.
- H. Provide a list of the UT when each Macro was executed. Attachment 7 lists the proposed contents.
- H. Put the FPA B Temperature in the scene header.
- H. Output CONVERT Version and build number if executed without arguments.
- H. Add the IFR start-scan time.
- H. Add the missing error types to the error log.
- H. Correct a spooling bug, IFR Data Products Error.
- H. Make selectable + / -maximum for the ZPD in the IFR section as a non-certified option.
- H. Cause an error message to be displayed when IFR is run without detectors selected.
- H. Add phase correction certification options to the IFR section.
- H. Tweak the IFR clock sampled wavelength to correct it.
- L. Correct the IFR linearity for small signals.
- L. Modify Pointing CONVERT to work with Pipeline output as the input.
- L. Correct the Pointing CONVERT output difference between EL and MS modes.
- VL. Add a super-pixel scene capability to CONVERT.

GLOBAL MINIMIZATION OF ERRORS

The Midcourse Space Experiment program is working toward a Global Minimization of the errors in the SPIRIT III instrument's data. This requires a correction for the instrument's characterized error sources in the data reduction process. The current plan is to have the CONVERT Version 6.0 data reduction process include all known corrections. The Principal Investigator team's data analysis is predicated upon accurate data. Pending the release of CONVERT Version 6.0 the respective Principal Investigator team's analysis is progressing with the interim Versions of CONVERT. The Certification of CONVERT Version 6 by the DCATT, the Global Minimization of errors and the concomitant completion of the PI Team's data analysis necessitates carefully coordinated technical work to complete the MSX Program's commitments in a timely manner.

A meeting at the Space Dynamics Laboratory Utah State University was held to discuss the following topics in detail.

1. A schedule for the CONVERT Version 6.0 milestones and what are the priorities for these milestones.
2. The Global Minimization of errors
3. The CONVERT 5.0 data archive.
4. A plan to support the Principal Investigator team's data analysis with the CONVERT Version 6.0 data accuracy concurrent the DCATT's Certification Processing.

CONVERT 6.0 Schedules & Priorities - CONVERT Version 5.3 will incorporate the IPs for integration mode normalization, responsivity versus temperature, irradiance responsivity, radiance responsivity, the scan mirror transfer function and optical distortion which would be used in CONVERT Version 6.0. It is noted the Point Response Function over the Field of Regard is an analysis tool and will not be incorporated into CONVERT. Two tasks, reported in a Trip Report to the Program Office as Attachment 1, numbers 16 and 20 are rescheduled to be completed after task number 41 so the regression tests of the radiometry can proceed.

CONVERT Version 6.0 code can be delivered to the DCATT to proceed with radiance only certification processing in June. A distribution to the Principal Investigators with a Draft Users Manual is set for mid-July of 1998. The release of the code to a broader community is set for September 1, 1998. The DCATT responses on the Users Guide review are due to Space Dynamics Laboratory Utah State University by June 30, 1998.

Sections of the CONVERT Version 6.0 Calibration Report will sent out to the DCATT as they are completed. A complete response from the DCATT to the Space Dynamics Laboratory Utah State University by October 1 and sections will be returned as the DCATT review is completed. Release of this report to the community is November and it will reference the Global Minimization of errors work.

A listing of the archived material through the release of CONVERT Version 5.0 was approved by the DCATT and the Program Office. All documents referenced by the Integrated Calibration Plan, the Users Guide and the Calibration Reports will be identified by Space Dynamics Laboratory Utah State University and the archive will be updated for the CONVERT Version 6.0 release.

A pointer to the DCATT's website will go through the Phillips Laboratory Data Analysis Center for the near term. A switch to a more permanent site will be transparent to users. This enables an earlier access to the DCATT Certification analysis.

PRINCIPAL INVESTIGATORS EXECUTIVE COMMITTEE

The Principal Investigators Executive Committee meets periodically to address the Program's activities. This includes reports from the individual Principal Investigators as well as a discussion of the current technical issues and plans to resolve them and Peer Reviews of the technical work.

MEETINGS

Detailed meeting minutes are compiled by Photon Research Associates for the Midcourse Space Experiment Program Office.

July 22, 1997

The Definitive Attitude for the spacecraft has continued to be a major technical concern. The causes of a residual spacecraft attitude error in the Definitive Attitude are being sought and alternative methods of processing the star camera and the gyro data to obtain a less uncertain Definitive Attitude are being pursued. An update on the alternative data processes, one by the Lincoln Laboratory Space Surveillance team and the Applied Physics Laboratory Attitude Processing Center team, as well as a status report on the search for the causes occupied more than half a day of this two day meeting and the Earth-limb Peer Review and Principal Investigator Reports occupied one day. A Definitive Attitude Report, a briefing submitted to the Program Office along with a Trip Report, informed the committee of the progress made to reconstruct the Earth Centered Inertial Pointing with as high an accuracy as practical, the expected accuracy limit within the scope of the currently implemented plan and the plans to improve the accuracy.

The Space Surveillance Attitude Report described a batch process to estimate a Definitive Attitude and reported on the performance improvement to be expected from a re-calibration of the star camera.

A Pointing Performance Assessment Team Conference Call briefly interrupted this author's participation in the meeting without significant impact.

The results of a Monte Carlo simulation of a star camera with a calibration uncertainty of $15 \mu\text{r}$ Noise Equivalent Angle produces a Definitive Attitude which is uncertain in roll, pitch and yaw (rotation about the spacecraft's plus X, Z and Y axes) which can be as good as 140, 8 and $50 \mu\text{r}$ when five stars are tracked and which can be as poor as 220, 10 and 80 when as few as 3 stars are tracked. These values are consistent with the Definitive Attitude performance obtained for the spacecraft whose star camera has a comparable specification for calibration, a calibration which has known calibration residuals.

It was thought a re-calibration of the star camera to remove the residuals would improve the performance, i.e. reduce the Definitive Attitude roll and yaw uncertainties. The star camera re-calibration analysis performed by the Lincoln Laboratory team gave a star fit of 13 μ r, an improvement which is sufficiently small as to be questionable as to justifying the costs to change the current Definitive Attitude automated process. Especially since the primary cause of the relatively large yaw uncertainty is the cross-coupled roll error. The roll contribution to yaw uncertainty, a large number already, would be reduced but with the overall effect of having a negligible change in the yaw uncertainty realized.

It is noted a Definitive Attitude Process investigated by the Lincoln Laboratory staff shows promise to significantly reduce the star camera's roll uncertainty coupled into the spacecraft's yaw uncertainty. This process relies upon batch estimation where the entire Data Collection Event's attitude history is used. The Definitive Attitude process currently used by the Attitude Processing Center is a version of a Kalman filter, and does couple the star camera's roll uncertainty into the spacecraft's yaw uncertainty. A Lincoln Laboratory Definitive Attitude File was created for and tested against a Data Collection Event segment where the SBV camera could produce a Truth Attitude. The results showed a significant improvement in the spacecraft's yaw uncertainty. A test of a Lincoln Laboratory Definitive Attitude File created for a Celestial Background DATA COLLECTION EVENT by this process however, does show a significant uncertainty in spacecraft pitch relative to spacecraft yaw. This is a preliminary and yet unexplained and unexpected result. Additional effort by the Lincoln Laboratory Staff is to be expended to investigate as to whether their batch process improves the Definitive Attitude for the twenty three Validation Data Collection Events used to validate the current Definitive Attitude Version 05 process.

An Action Item which had been open since 1996, to illustrate the Pointing Error induced by the star camera, is closed as a result of the improved understanding of the issues. The Definitive Attitude Status briefing presented at this meeting led to the improved understanding. Previous attempts to close this item, including a briefing to the Principal Investigators in January, 1997, were unsuccessful.

The Star Identifications, SIDs, extracted from the Low Rate Wide Band data stream had been extracted and made available to the Lincoln Laboratory Staff to use in their batch estimation process. These are the star camera output signals for the up to five stars it detected. This signal is used to estimate the spacecraft's attitude both on board the spacecraft and for the Definitive Attitude process on the ground after the Data Collection Event. The data for the gyro drift error measurements, also provided, formed the input for the Star Camera re-calibration work.

As stated in a Trip Report to the Program office, dated April 15, 1998, the question of what is "truth" for a Definitive Attitude of the spacecraft's commanded Earth Centered Inertial pointing remains unanswered. It is rather straight forward to test the EARTH CENTERED INERTIAL pointing achieved by using observed astrometric star positions. However, the motion of the spacecraft deduced as the Definitive Attitude may contain real spacecraft motion as well as virtual spacecraft motion. The virtual motion is any motion which is not real but which appears in a Definitive Attitude. A test to identify and remove this non-physical motion remains a challenge.

January 20, 1998

Each Principal Investigator reported on the significant activity within their respective area of responsibility and specifically reported on the respective team's progress with the Processing Analysis Notes. In addition to the significant activity report, the Data Certification and Technology Transfer team updated the Certification work on the SPIRIT III and the UVISI sensors. Two briefings were given to update the Principal Investigators on the effects the changes in the CONVERT 5 software for the SPIRIT III sensor and in the CONVERT 4 for the UVISI sensors. The analysts can expect to see an improved quality in the reduced data.

Three papers from the Early Midcourse team and three papers from the Earth-limb team were peer reviewed. These papers are to be presented at upcoming scientific meetings.

Progress by the Pointing Performance Assessment Team to resolve the programs' most significant outstanding technical issue, the reconstructed Earth Centered Inertial pointing, shows an uncertainty of less than 40, 100, 300 μ r rotation about Z, Y and X respectively. The X-axis is the line-of-sight. These results are from a 12 parameter, iterative fit using a batch estimator to align the star camera to the gyros. The fit is over the data collection event. The values are higher but consistent with a Monte Carlo simulation run with a 3 arc-sec, 1- σ error for the star camera which gave values of 8, 50, 140 μ r with 5 stars tracked. The performance degrades to 8, 80, 200 μ r when there are only 3 stars tracked. The briefing is included in the Executive Committee minutes of the meeting. The Space Surveillance team reviewed their batch attitude estimation process and its performance.

A question about an updated version of the SBV CONVERT arose from the Cooperative Targets team. Their reduced data was different from Lincoln Laboratory's for a specific Data Collection Event. The Cooperative Targets team were unable to duplicate the Lincoln Laboratory results. It appears there is a newer, uncertified version of SBV CONVERT. An action by the Program Office

will attempt to resolve the issue. Whether or not there will be a Certification of the revised CONVERT by the DCATT team is open for discussion. The changes made are to be understood first and then a decision made as to how to proceed will be made.

The Program Office has directed there be a formal Interface Control Document between the Applied Physics Laboratory and Lincoln Laboratory for the format and content of the data files which will serve as the input to the two batch attitude estimation algorithms, the Version 10 and the Version 20. Also, the fifteen Data Collection Events which had been selected within the Pointing Performance Assessment Team to guide pointing issue resolution for the POINTING PERFORMANCE ASSESSMENT TEAM Meeting of January 7, 1998 are to be reviewed for completeness and suitability to provide a relative performance comparison of a Version 10 and a Version 20 Definitive Attitude at the next POINTING PERFORMANCE ASSESSMENT TEAM meeting, mid-April, 1998.

The next regularly scheduled PI Executive Committee meeting is May 19-21, 1998, at PHOTON RESEARCH ASSOCIATES.

May 19, 1998

A Technical Transfer of Pointing and Alignment experience and lessons learned to the SBIRS High Contractor formed a significant element of the Mini_Pointing Performance assessment Team meeting. The SBIRS High Contractor also briefed the Midcourse Space Experiment team members on the Pointing and Alignment planned as of the Preliminary Design Review time frame for that program.

Lockheed Martin Missiles and Space Company presented the GEO and the HEO attitude Reference Systems. Johns Hopkins University Applied Physics Laboratory presented the status of the Definitive Attitude Version 10 process and an analysis of a suspected cause of some of the anomalous Definitive Attitude pointing behavior. Massachusetts Institute of Technology Lincoln Laboratory provided a status of the Definitive Attitude Version 20 process.

D. R. Haley's work, shows the Definitive Attitude Version 10 quality is effectively improved by the recursive estimation process implemented. However, when there are significant data drop-outs and excessively noisy data from the star camera the recursive implementation process appears to be unworkable. A more general batch gyro bias estimation algorithm is in-work. There is evidence which would lead an analyst to believe there is relative motion between the star camera and the gyros as well as between the SPIRIT III sensor and the star camera. A residual pattern of 100 micro-radian amplitude is observed in the Definitive Attitude for the Data Collection Events CB050100060 and CB050100061. The pattern can be

analytically reproduced by a 200 arc-s YX mis-alignment as one term of the gyro-to-gyro alignment covariance matrix. This would lead an analyst to conclude there is a gyro-to-gyro misalignment. D. R. Haley has begun an investigation into the possibility such an error may be real. Spacecraft time is available should a specific experiment be designed to obtain data which would support or disprove the mis-aligned gyro hypothesis.

Distribution of the Definitive Attitude Version 10 files will begin upon completion of final agreements with the Data Management team and upon receipt by the Attitude Processing Center the updated Data Collection Events list for which a Version 10 file is to be produced.

NIST'S ANNUAL BALLISTIC MISSILE DEFENSE ORGANIZATION METROLOGY REVIEW

The Midcourse Space Experiment Program of the Ballistic Missile Defense Organization has been represented at the Ballistic Missile Defense Metrology Project Review, held annually at the National Institute of Standards and Technology, for the past seven years. The National Institute of Standards and Technology work has directly supported the Midcourse Space Experiment Program's Reference Sphere material properties characterization with emittance measurements made in the Low Background Infrared Facility and the Infrared Detector Standards work has helped to characterize the unexpected dark offset temperature behavior of the SPIRIT III infrared detectors.

The tenth annual metrology review was held at the National Institute of Standards and Technology, Gaithersburg, Maryland on December 16 - 17, 1998. The "Proceedings of the BMD Metrology Review" are published by the National Institute of Standards and Technology. Current work of particular current interest to Ballistic Missile Defense Organization is the development of the Medium Background Infrared Calibration chamber, the spectral capability now operational in the Low Background Infrared Calibration chamber, the Infrared Filter Measurements and Standards and a National Institute of Standards and Technology initiative to establish a Radiometric Calibration Standards capability in space using either or both the International Space Station or the MIR. The United States interest may well be in support of the SBIRS High and Low programs, the Ballistic Missile Defense Organization's Theater Missile Defense, National Missile Defense and technology development, NASA's Mission to Planet Earth as well as that of basic science.

The annual metrology review meetings afford the benefactors of this metrology work, the staff of the various Ballistic Missile Defense programs, an opportunity

to interact with the National Institute of Standards and Technology staff. The interaction identifies those specific technical areas where additional work is required and coordinates the work in progress.

A briefing, Space Based Radiometric Standards by David B. Pollock and Thomas L. Murdock, presented by Professor Pollock, describes an evolving need for National Institute of Standards and Technology quality radiometric standards in space. This briefing has been provided to the Midcourse Space Experiment Program Office as an attachment to a Trip Report on this meeting. The Midcourse Space Experiment, which demonstrated the technology whereby Systeme Internationale (SI) traceable radiometric standards can be realized in space, is used in the briefing as example of how these standards can be achieved.

A summary of the individual presentations follows.

William Ott, finishing his last year as a Deputy Director Physics Laboratory, reported the National Institute of Standards and Technology hires about 3000 people. The \$270 million annual budget has remained stable for the last three years.

Robert L. Hinebaugh, Program Manager, Ballistic Missile Defense Metrology, reported the Ballistic Missile Defense budget from the Theater Missile Defense area is missing for this fiscal year. The Ballistic Missile Defense budget is approximately one third from Ballistic Missile Defense/T&E, National Missile Defense and Theater Missile Defense. The Theater Missile Defense portion funded the sapphire window work, a transfer radiometer known as the TXR and a refrigerator for the spectral LBIR facility. The TXR is jointly funded by NASA and Theater Missile Defense and has applicability to NASA's Earth Observing System's calibration work.

Eddie Japzon, Ballistic Missile Defense Organization, National Missile Defense Joint Program Office, states the individual program offices must fund the metrology and the SBIRS work is robustly funded. The POM process is about a two year lead time and although the 1999 POM had inadequate metrology funds, he is pursuing a change to the 2000 POM to increase the funding.

Chet DeCesaris reported there is a WIPT within BMDO/T&E which has identified risk reduction as a means of reducing overall program costs. In this specific instance risk reduction refers to improving the calibration and characterization of systems as they progress to the field.

Bob Mercer, AF, SBIRS Program Office, suggests the Ballistic Missile Defense community of scientists and engineers familiar with radiometric calibration and the

associated chambers is aging and training on Calibration Chambers within current Engineering School curriculum should be augmented to include such training. This is an opinion this author shares.

Reinherd Menzel, Hughes reports there are three SBIRS pre-calibration chambers in progress at Hughes. One of them will include the POST chamber as a calibrated source and another will include the MIC2 calibration chamber. The MIC2 chamber was used for the ground calibration of the MSX's SPIRIT III sensor. The primary calibration for SBIRS is planned to use stars.

John Davis, Boeing, Seal Beach, California, reports the LADS sensor will also be re-calibrated in-orbit with stars.

Multiple presenters described the significant effort being applied to sapphire. The work supports the development of the knowledge essential to have manufacturing standards applicable for controlling the costs and the risks to routinely produce sapphire domes and windows in quantities to support Theater Missile Defense applications. A nominal one quarter of the presentations at this review addressed sapphire.

Steven Lorentz reports the National Institute of Standards and Technology LBIR chamber incorporates the Absolute Cryogenic Radiometer, the United States SI traceable flux standard. It relates radiated power (a flux) to the absolute temperature scale via an electrical substitution radiometer (ESR). The Midcourse Space Experiment Reference Sphere material is scheduled to have its spectral emittance measured in the LBIR in the September-October 1998 time frame. A 7 cm diameter portable transfer radiometer for the Ballistic Missile Defense Organization is in construction. It is a low background instrument and is known as the BXR. It uses a Si:As impurity band conduction detector and a filter wheel for the near term, four to six months. It will eventually use a grating and order sorting filters. Its near term role is in support of the SBIRS and LADS calibration chamber evaluations. The chambers are the 7V at AEDC, the Boeing chamber at Seal Beach, CA and the new ones being constructed by Hughes which will incorporate the POST and the MIC2 chambers. Improved ACRs, ACRii and ACRiii, are in work. The ACRii will have a 10X sensitivity improvement and will continue to use Ge thermometers. Electrical improvements will provide a nominal 10 pw resolution. The ACRiii will use low a transition temperature super conductor edge to increase its sensitivity. Transfer standard detectors are available with a 10% Detective Quantum Efficiency but there are some biases still to be resolved. A comparison of the Detective Quantum Efficiency with the one measured by the manufacturer, Boeing (formerly Rockwell) is termed reasonable. These IBCs are repeatable to within 0.1% and the ACR uncertainty is 0.05%.

Timothy Jung reports direct emittance measurements can now be made in the LBIR facility. Only normal emittance is measured. Directional emittance measurements are not planned.

Joe Rice reports the MBIR will incorporate an ACR with the high sensitivity available by using a high critical temperature superconductor, a resistive edge at 89 Kelvins, with a 20 nW noise floor. The MBIR work is jointly funded by NASA and BMDO. A transfer radiometer, the TXR, a higher background flux instrument, is to evaluate chambers which support the Earth Observing System, EOS, work. The TXR uncertainty is less than 0.05% which equates to 150 mK. The TXR is a two channel instrument, 5 and 10 μm , with a 2° field of view. The short wavelength channel uses five InSb detectors and the longer wavelength channel uses 10 HgCdTe detectors. The Instrument will be put on the ESR scale.

Raju Datla reports the National Institute of Standards and Technology is the primary standard for Focal Plane Arrays. An InSb FPA is the transfer standard designed for the MWIR to support Ballistic Missile Defense Organization. A large aperture black body is being constructed to support NASA work. The black body is to work over the 200 to 400 K temperature range. Contact thermometry is used to by each supplier.

Leonard Hansen is evaluating neutral density filters for transmittance, reflectance and absorptance over the 0.2 to 1000 μm spectral range at 0.02 cm^{-1} and over the 1 to 100 μm spectral range at 0.05 cm^{-1} . The index of refraction is obtained over the 1 to 20 μm range from channel spectra. Polystyrene is a standard reference material over the 3 to 18 μm region and there are optical density one to four filters which cover the 2 to 25 μm region.

Simon Kaplan can characterize the out of band transmittance and the spatial uniformity of band pass filters with a Bomem FTIR. The noise floor is about 10^{-6} . The spatial sampling spot is about 35 μm in diameter.

Russ Walker reported the status of the Self Consistent Network of IR Calibration Stars and how they are developed. There is a hierarchy of standards. The primary standard to hundreds of microns wavelength is Sirius, α CMa, with an effective temperature of 9850 K; out to 10 microns wavelength Vega, α Lyr, with an effective temperature of 9400 K; and, Rigel Kent, α 1 Cen with an effective temperature of 5770 K. The total uncertainty reported is 1.45 % in the visible. The secondary standards are composite spectra for the first five stars and templates for the remaining. The tertiary standards, 422 stars, were sent to the Phillips Laboratory December 1, 1997.

Gerald Fraser reported the work directed toward the identification of wind tunnel

contaminants. The measurements take place during the less than ½ second blow down time for a supersonic tunnel. The temperatures are reportedly high.

Eric Shirley has available a computer program to calculate diffraction effects. It is available for the asking.

Allan Thurgood reported on the work to use a CVF radiometer to obtain a spectral calibration of an extended source in the MIC2 chamber.

Russ Clement from what was previously known as NOSC in San Diego, CA reports the direct emittance and transmittance work pioneered there continues.

Bob Mercer reported what the SBIRS architecture is. There are four GEO satellites, two HEO satellites and a number TBD LEO satellites.

Reinherd Menzel reported an over view of the SBIRS calibration facilities in work at Hughes. There are three chambers. One will incorporate the POST chamber. Another will incorporate the MIC2 chamber. The third is known as the E50. Hughes plans to calibrate their instruments in flight with stars.

John Davis reports the Boeing LADS sensor will be calibrated in flight with stars.

Of particular interest to the Midcourse Space Experiment program is the spectral capability for the Low Background Infrared facility has completed its initial test and evaluation. This facility is now ready to make the final set of measurements, the spectral emittance, of the Midcourse Space Experiment Program's emissive reference sphere materials. This work remains on the Low Background Infrared facility schedule and the tooling to support the measurements is still on loan from the Massachusetts Institute of Technology Lincoln Laboratory. The scheduled time for these measurements is early 1998, a date which could be improved if resources became available to support it. It is recommended support be provided. The spectral emittance used for the Data Certification and Technology Transfer's analysis of a sphere's radiance is based upon one minus the reflectance to get an emittance. Taking the difference in two numbers of nearly equal magnitude, the emittance is nearly one, provides a limited accuracy emittance. Massachusetts Institute of Technology Lincoln Laboratory has on loan to National Institute of Standards and Technology the fixtures that had been used to measure the total emittance of the reference spheres and sphere material. Spectral emittance was not measured directly when the spheres were being built because the Low Background Infrared facilities spectral capability was still in work. It is now in place and functional. Raju Datla, National Institute of Standards and Technology, states the reference sphere material's spectral emittance is still on the schedule, January, 1998, even though the Massachusetts Institute of Technology Lincoln Laboratory

is no longer involved. The quality of the Data Certification and Technology Transfer's sphere radiant intensity analysis would be improved with the reference sphere material's spectral emittance measured directly in the Low Background Infrared facility.

ISSEG MEETING

The ISSEG meets periodically to review work in progress such as the MSX Program and to make recommendations to the Department of Defense. Members of the ISSEG Panel are from multiple institutions and the United States Government. A briefing was prepared and presented at the March 11, 1997 meeting to document the status of the MSX Program's Data Certification effort. The briefing is part of the Panels records.

The MSX Program's Principal Investigator teams are dependent upon adequately calibrated data as an input to their respective analytical work. The Pointing and Alignment of the science instruments is still plagued by anomalous inaccuracies which anomalously appear. Also, the SPIRIT III and the UVISI CONVERTs have remaining biases which are being corrected by Versions of the respective CONVERTs which are in work at the respective Data Processing Centers. The message to the ISSEG Team is the Certification Effort is close to being complete. While a certain level of performance is realized with the current data inaccuracy, a cost benefit to all future data users accrues with the completion of the CONVERT changes and their respective certifications. The Certification effort schedule shows completion of the new versions of CONVERTs by the second quarter of fiscal year 1998.

UVISI WATCHDOG

The effort for this reporting period has been in support of the DCATT team's data processing to complete Data Certification of the nine UVISI instruments. The processing and analysis were primarily performed at Frontier Technology, Incorporated, Beverly, Massachusetts, by the Watchdog Team members there. The data analysis and instrument performance assessments for the UVISI Flight Certification Report, CONVERT Version 4.02 and POINT Version 3.2c were completed and the report prepared for publication. The DCATT's UVISI Level 2 data certification is based upon the processing and analysis of the Level 1A data acquired during the Data Collection Events listed in the Certification Report. The Data Collection Events are designed to explore the performance of each UVISI instrument within its' Operational Envelope. The data certification is based on end-to-end performance of the instruments, i.e., flux as an input to engineering units as the output. Thus, the instrument includes both the sensor hardware and software codes that reduce each instrument's raw radiometric and pointing data to

calibrated engineering units. Each Imager and Spectrographic Imager (SPIM) radiance and irradiance accuracy reported is the result of an RSS of bias, precision, truth uncertainty and, where appropriate, un-probed uncertainty.

DATA CERTIFICATION

The release of CONVERT Version 4.02 and POINT Version 3.2c to the Midcourse Space Experiment community differed from past releases in that it was done prior to the completion of the DCATT's certification processing and analysis. The release is based on the fact that "no gross errors" currently exist in this release of CONVERT and the DCATT plans to complete its testing by December 1, 1997 which will provide users with uncertainties for the CONVERT 4.02 outputs. The DCATT notified APL to make UVISI CONVERT 4.02 available on October 6, 1997.

The DCATT has analyzed multiple UVISI on-orbit characterization experiments conducted during the first year of the Midcourse Space Experiment. These events have been processed through CONVERT 4.02 and POINT 3.2C.

Stellar data has been processed through DCATT statistical analysis pipelines to characterize UVISI sensor accuracy and repeatability. Certification numbers for Imager Irradiance and Radiance, SPIM Irradiance and Radiance, SPIM Spectral Line Widths, Strengths, and Positions have been prepared. Imager Staring and Slewing and SPIM Pointing analysis has been completed.

SPIM4 Irradiance, Radiance, and Spectral Line Certification and SPIM4 Pointing analysis remains an open issue until a biased gain calibration issue is resolved.

The imager irradiances have large biases and widely varying precisions. Improved response curve normalizations, gain and gate calibrations may reduce the uncertainties.

Uncertainties calculated internally by the CONVERT and POINT software have been analyzed but remain uncertified as they do not match DCATT calculated values. DCATT recommends that the POINT software error analysis option in the Run Time Options (RTO) file be removed from the next release of UVISI POINT.

None of the HIGH GAIN data has been certified.

The certification processing and results presented by the Certification Report provide the certification of the UVISI instruments and the following UVISI DATA

PROCESSING CENTER inputs, products, and processes for the following quantities.

DCATT Certified UVISI DATA PROCESSING CENTER Inputs, Products, and Processes:

- UVISI CONVERT 4.02;
- UVISI POINT 3.2C;
- UVISI PIPELINE 4.0;
- UVISI OPERATIONAL ENVELOPE 2.0;
- IMAGER.ICAL 3.1;
- SPIM.SCAL 4.1;
- DEFINITIVE ATTITUDE FILES 05; and,
- UVISI HEADER RAW ATTITUDE

DCATT Certified Quantities:

- Imager Irradiance;
- Imager Radiance;
- SPIM Spectral Line Position;
- SPIM Spectral Line Width;
- SPIM Spectral Line Strength Precision;
- SPIM Spectral Irradiance, and
- SPIM Radiance.

The following UVISI Level 2A Pointing data products have been analyzed:

- Imager Pointing (staring);
- Imager Pointing (slewing); and
- SPIM Pointing (slewing).

The following quantities remain uncertified.

DCATT Uncertified Quantities:

- Imager and SPIM HIGH GAIN data;
- SPIM Pointing (staring);
- CONVERT/POINT Generated Uncertainties;
- SPIM4 Spectral Line Statistics;
- SPIM4 Spectral Irradiance and Radiance, and
- SPIM4 Pointing.

POINTING & ALIGNMENT WATCHDOG

The reconstructed pointing has made significant improvement to 100 μ r residual uncertainty and bias from 300 μ r residual uncertainty and bias. However, the cause of a bias as large as 100 μ r, which appears for some data collection events

and not others, is the subject of a concentrated analytical effort. This issue has been the primary focus of activity. The introduction of independent batch estimation processes by both the Attitude Processing Center and the Space Surveillance teams helped improve the Definitive Attitude process. An analysis of the Definitive Attitude data shows a possible mis-alignment of one gyro. The problem is the bias appears in some data collection events but not others. The Attitude Processing Center has an assigned person addressing the search for a cause of this bias.

To obtain a less uncertain Definitive Attitude, one that is of higher quality than the current 100 μ r quality, an approach was undertaken to improve the attitude estimate by a filter. "A First Report on Possible algorithms and Their Utility", July 7, 1998, is being prepared. It is to be submitted under separate cover upon completion of the work. This brief effort is to identify the required signal pre-conditioning and interpolation necessary to apply a constant or variable threshold, windowing of the data and low-pass filtering which should remove virtual spacecraft motion from the data.

POINTING REQUIREMENTS

GOAL \Rightarrow Reconstructed, Post Mission:

- Single Frame
 - SPIRIT III, < 9 μ r (1/10 Pixel)
 - UVISI NFOV Imagers, < 45 μ r (½ Pixel)
 - UVISI WFOV Imagers, < 450 μ r (½ Pixel)
 - UVISI SPIMS, <450 μ r (½ Pixel)
- Multi-frame
 - SBV: Fore-sight Pointing, 2 μ r (1/30 pix) & star fit, 6 μ r (1/10 Pixel)
- Spacecraft:
 - Jitter < 9 μ r / 700 ms
 - Open Loop Pointing < 0.1 deg (1.7 mr)

STATUS

- Pre-launch
 - Pointing Alignment Verification Test of the Process was successful.
 - 9 μ r Pointing is feasible
- Post- Launch Pointing Estimate
 - SPIRIT III and UVISI pointing derived from CONVERT and Definitive Attitude File
 - Result is <100 μ r
 - SBV (Does not rely on Definitive Attitude)
 - Fore-sight < 2 μ r
 - Star Fit Over Frame < 6 μ r
- Spacecraft Meets Specifications

- Jitter < 9 μ r / 700 ms
- Open Loop Pointing < 0.1 Deg (1.7 mr)
- Definitive Attitude Continues to Be an Issue
 - Reconstructed pointing estimate errors are <25 μ r some events
 - >100 μ r for many events with a clear bias in evidence

POINTING PERFORMANCE ASSESSMENT TEAM

The Pointing Performance Assessment Team meets periodically to assess the pointing and alignment of the spacecraft and the science instruments and to devise a plan of action to resolve issues when they arise.

MEETINGS

October 15, 1997

The Pointing Performance Assessment Team met at The Johns Hopkins University Applied Physics Laboratory in Building 4 Room 275.

This tenth working level meeting of the Pointing Performance Assessment Team provided additional insight into the Definitive Attitude Version 05 process as well as two mathematically independent attitude estimation batch processes, one is being done at the Lincoln Laboratory and the other at the Applied Physics Laboratory. The independent batch processes provide a Definitive Attitude cross check for those Data Collection Events where a SBV "reference" attitude isn't available. An Applied Physics Laboratory Definitive Attitude differenced with the Lincoln Laboratory Definitive Attitude produced for CB.02.01.00060.01 shows a mean difference and standard deviation of 576 & 12, - 659 & 14, 1 & 20 micro-radians for X, Y, Z respectively. The quaternions for each process plotted versus time overlay within the width of the plotted line. The star camera to gyro triad difference versus time show a reasonable behavior. The standard deviations are small and would be significantly smaller if the undulations, residual uncertainties were accounted for and removed. Although the X and the Y mean values appear to be relatively large, they may be simply a bias (an alignment), and overall the agreement is considered to be good. Note the SBV sensor was off for this Data Collection Event, hence there is no "reference". Also, this Data Collection Event would pass the Attitude Processing Center's Definitive Attitude Version 05 Quality Assurance checks.

Each of the two processes were described at this meeting and the Lincoln Laboratory process is further described by a presentation by M. Gaposchkin at the July 23 - 24, 1997, Principal Investigators Executive Committee Meeting (the Meeting Minutes are available from the Program Office). Either or both of the

batch estimators can lead to a Definitive Attitude Version 10, a more robust and accurate Definitive Earth Centered Inertial pointing solution.

There are still some Data Collection vents where a Definitive Attitude produced by the Definitive Attitude Version 05 recursive estimator or either batch estimator has spacecraft motion that is difficult to interpret a real, physical spacecraft motion. Examples are shown by the charts titled Star Camera / Gyro Triad / Differences (CB.02.01.00036.01) and Gyro-to-DAv5 differences CB.01.01.036 which were presented at the meeting. These two Data Collection Events would fail the Attitude Processing Center's Quality Assurance checks.

An investigation into the Star Camera's detected position detection and correction (sometimes called distortion correction, a valid statement which often leads to misunderstandings) has begun. While it is too early to draw final conclusions, the results indicate there are artifacts which need to be corrected.

An investigation of alignment issues such as those associated with a coefficient of thermal expansion effect is dependent upon the more accurate spacecraft attitude estimate, i.e. an attitude uncertainty demonstrated to be sufficiently small as to permit one to have confidence in observed alignment variations which might vary from on Data Collection Event to the next or during a Data Collection Event. The magnitude of spacecraft structure coefficient of thermal expansion effects on the respective science instrument's pointing remains an active area of investigation. The typical spacecraft temperatures for two Data Collection Events shown at this meeting are preliminary. Additional insight as to the sensor's exact location and the measured thermal changes would have on alignments remains to be understood.

A summary of the SPIRIT III's pointing performance with the Definitive Attitude Version 05 attitude file based upon the Benchmark Experiments, DC43s and DC44s, is shown by Attachment 12. Additional plots in this Attachment show the observed stars position and the projected stars position (projected with the Definitive Attitude Version 05) on the SPIRIT III focal plane show there is still progress to be made to remove biases. A word of caution, note the SPIRIT III's Optical Distortion is not removed for the DC33 and KDKCK35 plots shown in this Attachment.

The UVISI IUN data for CB.02.01.00060.01 is sparse and the data for IVN has too many stars, each smeared significantly, that a meaningful attitude history extraction is non-productive.

The improvement for the MDT II analysis contributed by the SPIRIT III radiometric instrument products files, CONVERT Versions and Definitive Attitude Versions is evidenced by plots which compare the SPIRIT III pointing

vector with one obtained from ground observations of a test object. The errors are still on the order of 100 micro-radians.

January 7, 1998

The Pointing Performance Assessment Team met at The Johns Hopkins University Applied Physics Laboratory in Building 4, Room 4-275.

This tenth working level meeting continued to focus on an identification of the cause(s) of the residual pointing and alignment inaccuracies. It would appear to be a simple task to find a problem since each science instrument can produce an attitude estimate as well as the star camera. The gyros produce the attitude rate estimate. Then we should need only to decide which attitude estimate is most nearly the “truth” and find the problems with the those that are further from truth. We have a problem. Simply stated there is no “truth”. Thus, only by comparing samples of estimated attitude over a period of time are we able to discern which attitude estimate is most nearly the “truth”. If there are only two samples of estimated attitude for a specific period of time, then a coin flip is a possible, but unsatisfactory, solution to decide which one is “truth”. The difficult task is the analysis to support a decision as to which attitude estimate over the same period of time is most nearly correct and then to identify a physical basis for why other attitude estimates over this same time period disagree. There are times when three estimates are possible and the task is some what ameliorated.

Let us digress for an analogy. It is possible to prove an optical flat is flat to some quantifiable uncertainty. We proceed to make three flats. The process to use is an interferometric inter-comparison of the three parts. Each part is compared with the other two and the high spots are removed. When the three interferograms agree to an acceptable uncertainty, we know we have produced a flat surface to a quality which can be stated. The reduction of the interferograms rms wave front error into rms surface variation provides us with the quality statement. Were there only two parts to compare we could only prove a spherical surface of some quality.

When we have three attitude estimates we have to decide which to believe is most nearly correct. Is it the two which most nearly agree or is it the third? From a science perspective it is preferred to identify a physical cause for the agreements or the disagreements and proceed from there. Potential causes for a disagreement are the incomplete characterization of an instrument’s behavior or an error in the data transmission. An incomplete instrument’s or the spacecraft’s characterization can induce data sample-to-data sample effects which will increase the pointing uncertainty above the true error. A process error in a data samples’ reduction to an attitude estimate will also increase the pointing uncertainty above the true error.

A Definitive Attitude Progress Report lists four categories of Data Collection

Events, Class A, Class B, Class C and those on hold. A total of 1568 Events have been processed to create a Version 05 Definitive Attitude. Of this total there are 1389 which passed the Attitude Processing Center's Quality Check and were released to the community. There are 181 Events that failed the Quality Check and 23 Events that failed the Definitive Attitude Version 05 Computation process. The 33 Events on the hold list do not have Attitude Processing Notes.

The data in the Attitude Processing Notes of the 1200 to 1400 files for which a DA Version 05 were created formed the data base for some preliminary summary statistics. The mean of the "DA-Stars Error Avg" is 1.3, -2.5, 5.2 micro radians and the mean of "DA-Stars Error Std Dev" is 287, 106, 14.2 micro radians, rotation about spacecraft X, Y, Z respectively. The latter shows good agreement with the Monte Carlo statistics for the spacecraft pointing model, which were reported at the Pointing Performance Assessment Team Meeting, October 15, 1997.

(Some general comments are in order. What has been referred to as DA06 is to become Definitive Attitude, Version 10. Both names are used in the briefing materials attached. Also, the LL DAF may be referred to as Definitive Attitude, Version 20. The reader is cautioned to be aware. There are only two batch estimation processes. One which uses spline fits of the data to align the gyros and the star camera and one which uses a linear fit to correct for the gyro's offset and alignment.)

The SPIRIT III, Version 05 Definitive Attitude File based, pointing inaccuracy for the DC29s, DC33s, DC35s, DC43s and DC44s used to establish a baseline of performance and to characterize the SPIRIT III sensor is less than 60 micro radians. When a Version 10 Definitive Attitude File based pointing is compared to a Version 05 Definitive Attitude File based pointing for a selected, agreed upon set of test Data Collection Events, a SPIRIT III subset of the 15, the Version 10 Definitive Attitude File gives a more uncertain cross-scan result and a less uncertain in-scan result than the Version 05. The increase in the cross-scan uncertainty may be real or it may be an artifact due to some residual and as yet unidentified error source. Further analysis will be necessary to resolve issues such as this.

When a Version 10 and a Version 20 Definitive Attitude File is produced and compared for the selected, agreed upon Data Collection Events, there are residual errors which range from less than 10 μ r to greater than 100 μ r within the event.

A Version 10 Definitive Attitude File was created for 15 Data Collection

Events and distributed to the SPIRIT III, UVISI, SBV, the Early Midcourse Team and the Space Surveillance Lincoln Lab Team for evaluation and analysis. The majority of the meeting discussed the results from the respective analysts. After a careful review of these presentations and having participated in the discussions, it is suggested more thought and analysis is required before conclusions are stated. In the interim as additional thought, discussion and analysis continues, work is proceeding to provide a Version 10 Batch Estimated Definitive Attitude File for selected Data Collection Events.

There remain unanswered technical issues: is there significant spacecraft flexure; are there real and significant alignment shifts; if there is either, then which instrument is shifting or flexing and what is the magnitude and the time period; under what conditions does a shift or flex occur; does the star camera need to be re-calibrated in-orbit; do SBV, IVN, SPIRIT III and the star camera all give the same pointing solution for the DC2903s; are the SPIRIT III pointing errors comparable in EL and MS mode; does the Definitive Attitude Kalman filter need another parameter or existing parameter weights adjusted further; what is the improvement magnitude when a smoother is implemented; all remain unanswered.

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